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Variable Hit or Miss Transform Based Feature Extraction Inlidar For Robotics Application

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Abstract

The Hit or Miss Transformation (HMT) is a well-known morphological technique which can be used for shape and object recognitionin Digital Image Processing. When standard HMT is used for shape detection it may fails, because of fixed size of structuring element.Laser Rangefinder (LRF) is used to measure a distance at the closed region, which is working under the principle of "Time of Flight". Collected data's are used for the HMT process. To detect the shape with variable size of structuring element in image, a new technique is proposed called Variable Hit or Miss Transformation. The proposed technique is used to detect shapes in effective manner with high accuracy. This technique is useful for the application of mobile robot localization in indoor environment.

Keywords: Standard Hit or Miss Transform (HMT), Structuring Element, Laser Rangefinder (LRF), shape detection, Variable Hit or Miss Transform (VHMT)

Introduction

In the application of mobile robot localization, laser rangefinder is used to measure a distance between position of rangefinder and objects.Number of techniques is available for the mapping and localization with the measurement of distance. 2D environment mapping in indoor environment was proposed in [1] and this used segmentation based distance measurement which is principle of "Time of Flight". Cartesian coordinates based feature extraction,in[2]used the technique geometric invariance because it depends on the condition like membership function. Self-governing robot can localize the surroundings based on map building. In [3] propose ultrasonic sensor to scanning the location and the collected data's are used for map building and localize it.Mobile robot path planning is the major issue it is difficult to reach starting point to end point [4] method used to recover in indoor localization

node selection rules and to choose the shortest path to reach the end position. Line and edge based localization was present [5] propose hybrid localization technique. To find the solution for the family indoor localization problem. In [6], propose the hybrid localization to solve all those problems like obstacle avoidance, path planning, corner detection and straight line detection.

Morphological Hit or Miss Transform (HMT) is used for detecting similar shapes. Binary image and the structuring element (SE) are taken as input, SE inquiry with the original image to gives the information about detection or absence of objects [10]. Roof top of the building was derived from very high spatial verdict [7], employ percentage occupancy hit or miss transform (POHMT). Methodology of Hit or Miss Transform is perfectly adopting for finding shapes. Later it is used to extract features from the noisy image.Detection of building in very high spatial resolution is difficult one in [7] extract building location and compare the three satellite image with percentage occupancy level. In [8], building separation of rural area was proposed.

Morphological opening and closing technique are used to classify the building, second think is extract the features based on the classification and finally neural network was used to found the extracted building with high accuracy. In this paper [9], Damaged building detection like Tsunami affected area are classified using morphological operation such as opening and closing. In [11], proposes technique to detect both the perfect and imperfect shapes.In this paper proposes an image processing technique such as mathematical morphological Hit or Miss Transform (HMT) is modified as Variable Hit or Miss Transform (VHMT) for extracting the shapes using Laser Range Finder (LRF) data's. This technique is useful in mobile robot localization in indoor environment.

Objective

The main objective of this paper is to develop a technique for feature extraction based on the Laser Rangefinder (LRF) data's. The extracted shapes are helpful for robot localization and mapping. Morphological Hit or Miss Transform with variable size of structuring element is applied for the feature extraction of shapes.

Methodology

Laser Rangefinder (LRF)

Figure 1: HOKUYO ® URG-04LX-UG01 Scanning Laser Range Finder

It is a rangefinder which is used to find distance to an object by using laser light.The principle of Laser rangefinder is "Time of Flight" it states that drive range from the time it takes light to travel from the sensor to the target end return.

Table 1: Specification of HOKUYO ® URG-04LX-UG01 Scanning Laser Range Finder (LSR)

Name	Scanning Laser Range Finder
Model	URG-04LX-UG01
Light source	Semiconductor laser diode (λ=785nm), laser safety class 1
Power source	5v DC
Current consumption	500mA or less
Detection distance	20mm – 4000mm
Accuracy	±30mm
Scan Angle	240 degree
Angular Resolution	0.36 degree
Scan time	100msec/scan
Interface	RS-232C (19.2, 57.6, 115.2 kbps) USB Version 2.0 FS mode (12Mbps)
Noise	25dB or less
Weight	160g

Light Detection and Ranging

Light Detection and Ranging (LIDAR) is one of the most accurate methods to measure the indoor environment. Light source is reflected well in natural environment

when compared to sound waves and longer wavelength signal. It has smaller wavelength, it detects smaller as well as the larger objects with high resolution. In the proposed technique LIDAR is scanning around 240 degree with 4m distance. Laser scanned data's are converted into image it has 200 pixels with 0.0004m resolution.LIDAR has high resolution when compared with sonar and radar. The reflected light from the object can be used to detect the distance from the target. This makes LIDAR more adaptable for short range autonomous mobile robot. Measurement of distance with high resolution is done with Light Detection and Ranging system.

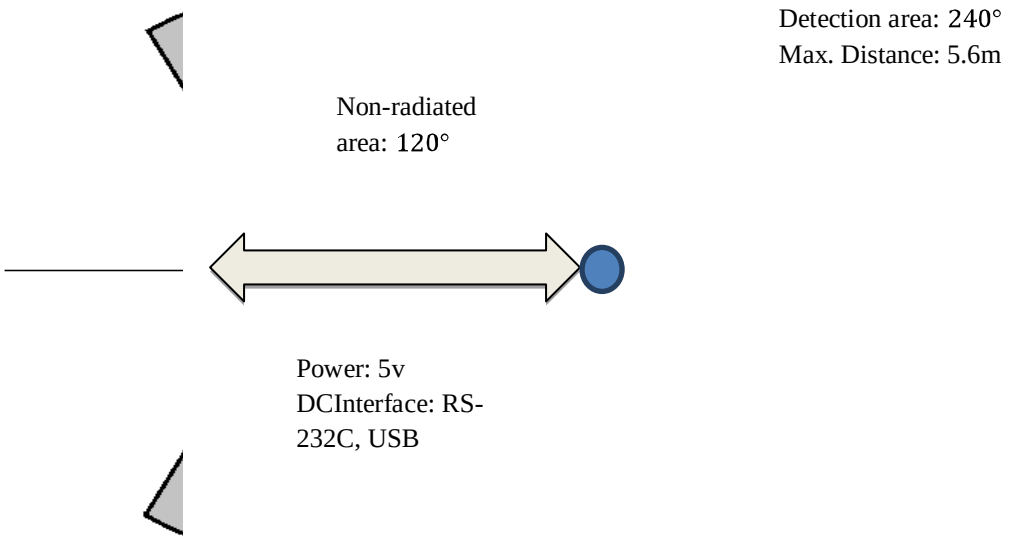

Figure 2: Scan the Target

Based on the principle of Time of Flight laser range finder is measure the distance between position of rangefinder and object. It is working difficult in open source to find the long range that's why it operated at enclosed region.Light source is emitted from the transmitter in laser rangefinder when it reaches the target reflect back to the receiver. Clocking electronics count the pulse while it started to emit from the transmitter. At the time of receiving pulse from the target the clocking electronics automatically stops the counting. Range display is used to display the range of distance in between the sensor and target.

Hit or Miss Transform

The Hit or Miss Transformation (HMT) is a well-known morphological technique which can be used for shape, object recognition and feature extraction in Morphological image processing. Hit or Miss Transformation operation takes binary image and a Structuring Element (SE). Binary image and Structuring element (SE) are

taken as input and using HMT operation to get output. Mathematical expression of HMT

$A \odot B = (A \ominus C) \cap (A^C \ominus D)$

Where, A- Original Image, C- Structuring Element

D- Complement of Structuring Element

A^C- Complement of Original Image

$\odot$ - Hit or Miss Transform Operator

$\ominus$- Erosion Operator

Erosion of Binary image by the first structuring element and erosion of complement of Binary image by the second structuring element are intersecting to gives the hit output. HMT mainly uses the structuring element that is shape used to probe or interact with the original image with the purpose on how the shape Hits or Misses the shapes in original image. Structuring element size was constant in all process such as automatic detection of building shapes, detecting shapes from original image. Based on this methodology able to detect only the shapes based on the structuring element hundred percentages Hit or Miss the images. The perspective methodology is naturally increasing the size of structuring element, adopt for shapes in original image and Hit the shapes.

In the proposed methodology first detect the shapes in horizontal and vertical based on the laser rangefinder (LRF) data's. Morphological image processing, Erosion is the operation, using this one the structuring element probe with original image foreground pixels occupy with SE and background pixels completely misses the shapes.

Let Euclidean space (E) and binary image (A) then erosion of Binary image A by Structuring Element (SE) B is defined as

$A \ominus B = \{z \in E \mid B_z \subseteq A\}$

Where $B_z = \{b + z \mid b \in B\}, \forall z \in E$

Structuring element B located in center of the origin, when B moves inside a binary image.

Structuring Element

Structuring element (SE) is shape used to mesh with the original image with the reason of conclude by means of the shape fits or misses the shapes in the original image. It is defined by two main things such as shape and size. Size of the SE represents as pixels in binary image like white and black indicated respectively 1 and 0. Shape of the SE is pre defined based on the original image and the size also gave as observation scale like binary matrix contains zero's and ones. When SE have match with original image results hit represents one (1) otherwise it misses represents as zero (0).

Structuring element of the process is small compared to the original image which is going to be find objects in it. When the origin of the SE is probe with original image, compare pixels in the SE with pixels in the original image.

If the pixels of SE matches then the result gives hit image. SE plays a main roll in pattern matching with pre defined structure of shapes. Privious concept about SE used in shape and object detection as constant size.

Variable Hit or Miss Transform

Standard HMT used for the detection of shapes in image, it detects shape only based on the constant size of structuring element. Using this method it may fails to detect the many number of shapes also accuracy level get reduced. That's why propose a new technique called Variable Hit or Miss Transform (VHMT). This technique is used to detect shapes, here the size of the structuring element is automaticaly adopted to that shape and hit the image. Size of the SE is automatically increased to that original image find the maximum number of shapes with high accuracy.Using this proposed method to find the horizontal and vertical line based on the scanned data's. collectlaser range finder data's and then convert it into scanned image. Doted lines of scanned image is dilated using morphological operation. It enlarges the pixel size whatever in the scanned data. After the dilation take it as for the process of Hit or Miss Transform. Structuring Element is created based on the original image.

Two set erosion operation is done with that original image and the structuring element. First the automatically incrementing structuring element is erode with original image it shrinks the pixels in size. Second the complement of structuring element is erode with the complement of original image. These two erosion operations are intersecting to gives the hit image with reducing pixels. Both the horizontal and vertical lines are detected base on the above mentioned procedure. After getting the output of hit ot miss transform dilate the image to enlarge the pixels.

Results and Discussion

Theperformance of the proposed technique is verified using MATLAB coding. Scanned Laser data's are collected and implemented for the process Variable Hit or Miss Transformation.

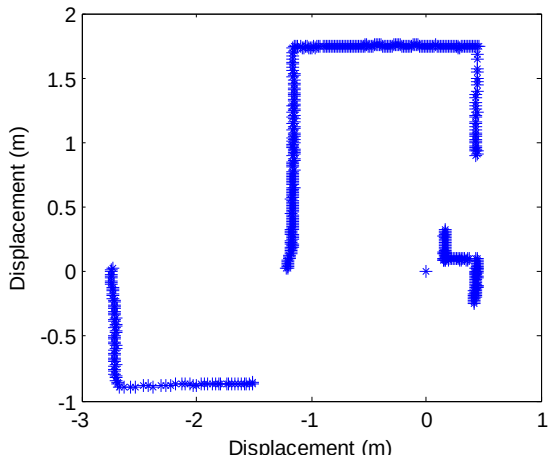

Figure 3: Shows The Axis Plot of Original Image In Fig. 4

Figure 4: Original image

The dilated image shown in Fig. 4. Scanned data's are in the form of doted line, after that it is dilated using the morphological operation.

Horizontal Line Detection

Fig.5 Hit or Miss Operation base on the Laser Rangefinder Data (a) Original image, (b) complement of original image, (c) Structuring Element, (d) Complement of Structuring Element, (e) resulting image of (a) and (c), (d) Resulting image of erosion of (b) and (d)

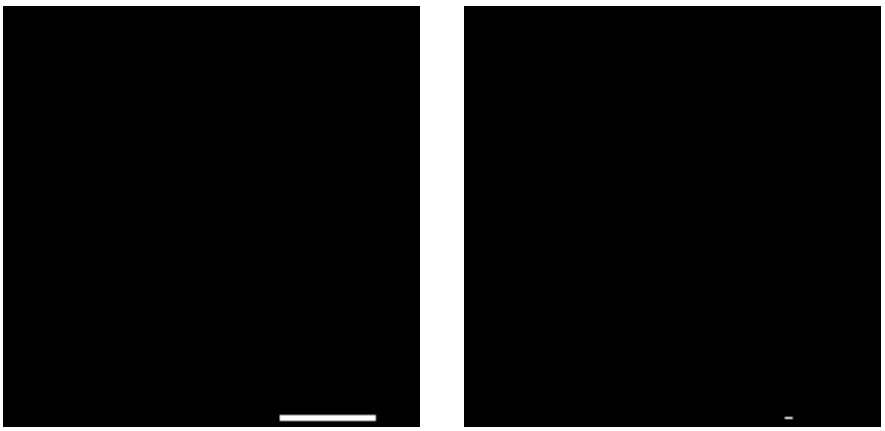

Fig. 7 Result of Hit image at final stage for Horizontal line detection

Dilated image is taken as the original image, based on that image create structuring element for shape detection. Fig. 5(a) & (c) are original image and structuring element respectively perfom with Vareiable Hit or Miss Transform to gives the output shown in Fig. 5(e). Fig. 5(b) & (d) are the complement of original image and structuring element respectively perform with the VHMT to gives the output shown in Fig. 5(f).

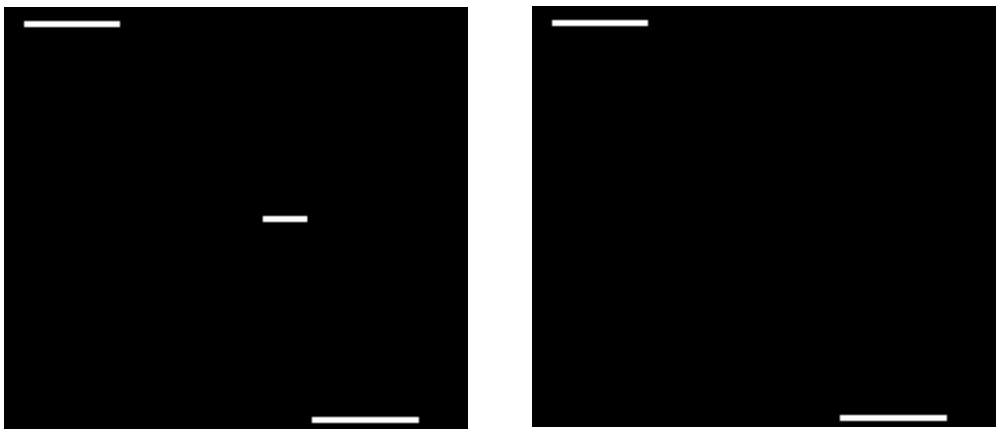

Figure 6: Result of Hit image at initial stage for Horizontal line detection

Variable Hit or Miss Transform performs with two set of erosion operation and it gives the result at the initial stage of VHMT operation as shown in Fig. 6. It hit the shape in horizontal line during the automatic increment of structuring element.

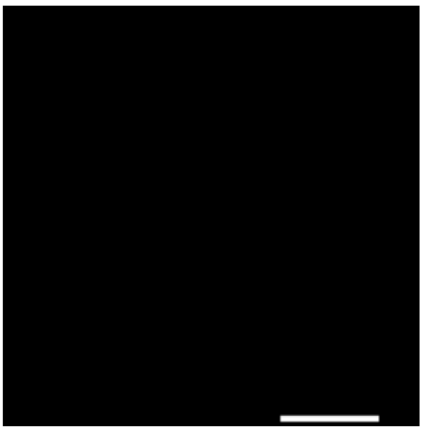

Fig. 7 Result of Hit image at final stage

The operation of VHMT operation during the automatic increment of structuring element at final stage is shown in Fig. 7.

Vertical Line Detection

Original image and structuring element are shown in Fig. 8(a) & (c) structuring element is created based on the original dilated image. It performs with VHMT to gives the result in Fig.(e).

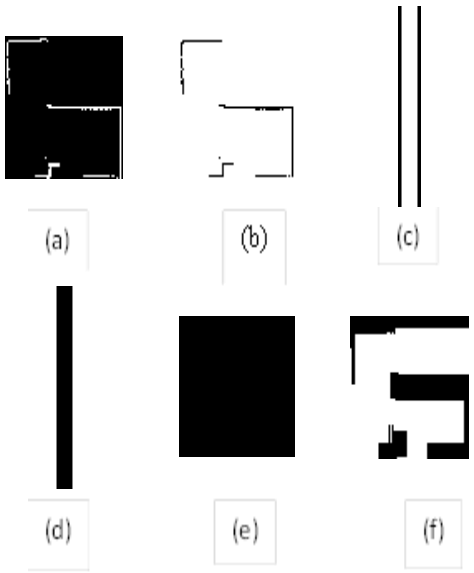

Figure 8: Hit or Miss Operation based on the Laser Rangefinder Data for vertical line detection (a) Original image, (b) complement of original image, (c) Structuring Element, (d) Complement of Structuring Element, (e) resulting image of (a) and (c), (d) Resulting image of erosion of (b) and (d)

Complement of original image and structuring element are shown in Fig. (b) & (d), it performs with erosion operation to gives the result in Fig. (f).

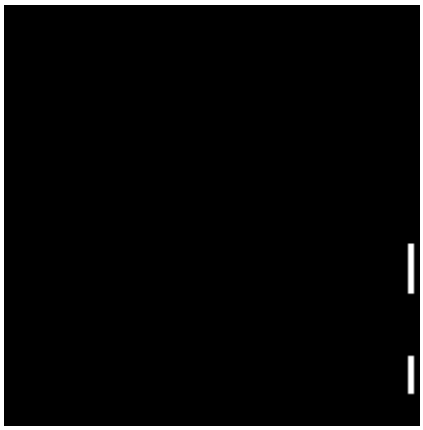

Figure 9: Result of Hit image at initial stage for vertical line detection

VHMT performs with variable size of structuring element to gives the result shown in Fig. 9. It shows the automatic increment of structuring element at the initial stage.

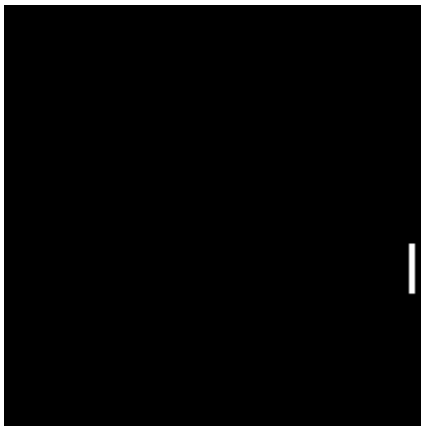

Figure 10: Result of Hit image at final stage for vertical line detection

Horizontal line detection with automatic increment of structuring element results at final stage shown in Fig. 10. Proposed Variable Hit or Miss Transform gives the results with high accuracy shape detection.

Conclusion

This paper proposes a novel technique called Variable Hit or Miss Transformation (VHMT) for the purpose of shape detection. Structuring element used for shape detection was constant in exiting methodology. Novelty of this paper is varying the size of the structuring element in VHMT. Laser scanned data's are collected from Laser Rangefinder and implement it in the process of VHMT. Two set of erosion operations are intersecting to gives the hit result such as horizontal and vertical line based on the original dilated image and the varying size of structuring element. In this method shape detection is done with the high accuracy of hit image.

Future Work

Horizontal and vertical line detection is proposed in this paper. Future work of this project is to detect the shape like 'L' and this is implemented in mobile robot localization. Feature based mobile robot localization process has uses the technique it gives more robust localization with high accuracy.

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